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ORCHESTRATING DOMINANT BATTLESPACE AWARENESS

By

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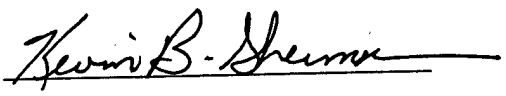
A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal view and are not necessarily endorsed by the Naval War College or the Department of the Navy.

Signature: 

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Joint Vision 2010 expresses the vision of a revolution in military affairs through the transformation of maneuver, mass, logistics, and operational protection into four new operational concepts. Although technology is forecast to improve these concepts, JV 2010 shows the prism of information superiority to be the catalyst for dramatic improvement. This paper will focus on the real time awareness piece of information superiority that is called dominant battlespace awareness (DBA). Specifically, the paper examines achieving DBA through the perspective of intelligence, surveillance, and reconnaissance collection. The organization of the early air defense organizations is used as a historical template for creating assured awareness from disparate pieces of information. An expectation of achieving DBA is naïve without organizing to achieve it. Although complete awareness is unrealistic, an early and well developed ISR plan can achieve the pockets of battlespace awareness that are sufficient for the "new operational concepts". Real-time DBA requires the orchestration the ISR collection sensor at the operational level of war.

TABLE OF CONTENTS

Orchestrating Dominant Battlespace Awareness

While technological advances have the potential to dramatically alter the quality and character of the traditional battlespace functions of maneuver, strike, protection, and logistics, JV 2010 asserts that information superiority will transform them into the four new operational concepts---dominant maneuver, precision engagement, full-dimensional protection, and focused logistics...

Concept for Future Joint Operations:

Expanding Joint Vision 2010[1]

I. INTRODUCTION

Intelligence support to national and theater decision-makers was excellent. ...
Tactical commanders considered intelligence support at the division, wing and lower levels insufficient...

Conduct of the Persian Gulf War Final Report to Congress[2]

The evolutionary path that has been set for our Armed Forces is based on a capability that we have not yet achieved: information superiority. Although the attainment of information superiority consists of many components, the awareness of an adversary's presence, movement and actions within the battlespace is the most fundamental and challenging. Further, the ability to meet the real time intelligence requirements at the tactical level, a capability not achieved during the Gulf War, is fundamental to making Joint Vision 2010 a reality and must be orchestrated at the operational level of war. The Joint Force Commander (JFC) controls the intersection of national, theater, and tactical intelligence systems and is thus responsible for managing how intelligence, surveillance, and reconnaissance (ISR) sensor information is fused into a "picture of the battlespace".

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[1] The Joint Chiefs of Staff, Concepts for Joint Operations: Expanding Joint Vision 2010, May 1997, 38-39.
[2] Department of Defense, Final Report to Congress: Conduct of the Persian Gulf War, July 1992, C-18.

The challenge presented by dominant battlespace awareness (DBA) is to create and sustain this fused picture of adversary forces, friendly forces and the environment within the battlespace.[3] The process of creating battlespace awareness can be broken into two components: preparation and real-time collection. The real intelligence success of the Gulf War was the pre-engagement collection and analysis of Iraq's force capability, disposition, and the Iraqi environment (geographic, physical, meteorological, etc.). This intelligence preparation of the battlefield was achieved through the systematic use of the products from largely stove-piped national, theater and tactical ISR systems with the benefit of the factor of time.[4] The success of the precision air attacks of Desert Storm as well as the rapid maneuver and penetration of Iraqi ground defenses are indisputable tributes to this intelligence preparation effort. The second component of battlespace awareness is the recognition of what is happening or changing in the battlespace right now. This is a more difficult challenge and the most relevant to the tactical commander. This examination focuses on the process of real-time ISR collection required to achieve dominant battlespace awareness.

The resources available to collect this real-time battlespace awareness are the intelligence, surveillance and reconnaissance sensor systems. The most common expectation of a battlespace picture is that which is currently provided by air surveillance radar systems. Airspace is a fairly transparent environment and systems like the cooperative engagement capability (CEC) have already demonstrated the near total awareness of the airspace that DBA requires of the battlespace.[5] Joint Vision 2010 has the further requirement to achieve a similar awareness of the surface of the battlefield. This awareness of the surface is

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[3] The Joint Chiefs of Staff, Joint Vision 2010, undated, 13.
[4] Department of Defense, Final Report to Congress: Conduct of the Persian Gulf War, July 1992, C-6 - C-9; Kenneth R. Israel, "DARO Vision for the Next Millenium", Proceedings of the Intelligence, Surveillance, and Reconnaissance Conference, Association of Old Crows, Moffett Field, CA Nov. 18-20, 1997, 15-16.

considerably more difficult because the individual ISR sensors provide a partial picture of any activity and the surface environment (i.e., terrain, vegetation, and weather) further restricts this awareness. Thus, how well the different ISR sensors work together defines the transparency of the battlespace awareness picture.

The importance of this synchronization of ISR sensors becomes paramount under Joint Vision 2010 with its reliance on information superiority. This importance of information superiority to realizing JV 2010's new operation concepts is most powerfully expressed as: assured operational success is dependent upon assured information superiority. This need for assurance does not just imply the need to protect information, but more importantly the need for a high probability of detection and recognition of an adversary. This aspect of assured awareness raises the stakes for achieving dominant battlespace awareness and can be used as a standard to evaluate the processes, which can achieve it.

The use of an ISR collection viewpoint permits an exploration of the role of the Joint Force Commander (JFC) in creating dominant battlespace awareness. The JFC's task can best be understood by examining the collection challenges of dominant battlespace awareness, some limitations of the intelligence collection disciplines, current collection doctrine, and ISR collection's role in the leading paradigms for a revolution in military affairs (RMA). A brief look at the early United States air defense organizational model for achieving assured detection of potential bomber attacks during the 1940's and 1950's provides an historical filter that can be mated to today's paradigms. This focus on the process and organizational changes required to achieve dominant battlespace awareness at the operational level of war is fundamental to achieving Joint Vision 2010.

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[5] Arthur Cebrowski and J. Garstka, "Network-Centric Warfare Its Origin and Future", U.S. Naval Institute Proceedings, January 1998, 33-34.

II. Dominant Battlespace Awareness Requirements

Dominant Battlespace Awareness

An interactive "picture" which will yield much more accurate assessments of friendly and enemy operations within the area of interest. Although, this will not eliminate the fog of war, dominant battlespace awareness will improve situational awareness, decrease response time, and make the battlespace considerably more transparent to those who achieve it."

--Joint Vision 2010[6]

Every field of endeavor has its own terminology and concepts which must be understood before further examination is possible and JV 2010 is no exception. Within the discussion of dominant battlespace awareness there are several ISR collection concepts that must be understood. Additionally, it is beneficial to have a better understanding of why real-time information is critical to successfully achieving the operational concepts of dominant maneuver, precision engagement, focused logistics, and full-dimensional protection.

Real-time situational awareness of an adversary in the battlespace underpins the four new operational concepts of Joint Vision 2010. Dominant Maneuver requires DBA to accurately position and employ joint forces throughout the battlespace.[7] Without real-time DBA JV 2010 forces would not be able to immediately adjust to an adversary's movements, would be slower to recognize and seize new enemy vulnerabilities, and would be more vulnerable to counterattack. Precision Engagement likewise requires real-time DBA to identify, engage, assess, and reengage as required.[8] Real-time information gives precision engagement a tempo well inside an adversary's decision cycle. Real-time DBA is required to achieve Full Dimensional Protection with an economy of force, by giving instantaneous awareness of threats and changing situations so that forces can be reallocated as needed. Focused logistics information needs are predominantly focused on own force awareness, but

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[6]The Joint Chiefs of Staff, Joint Vision 2010, undated, 13.

[1] Ibid, 20.

fewer supplies on the battlefield places much greater emphasis on the need for Full Dimensional Protection. This quick discussion of Joint Vision 2010's new operational concepts illustrates their reliance on an assured and real-time awareness of an adversary within the battlespace.

The process of ISR collection is best described by collecting pieces of an ever-changing puzzle. This collection analogy can be stretched with each sensor providing a different number of pieces, which vary in their color, shape, and texture. This analogy highlights the need for the collaborative use of different sensors in order to improve the clarity of the battlespace picture. This battlespace picture can be constructed more quickly if an operator or automated process can recognize an adversary's operational patterns. In this way an operator can look for the specific pieces of information that confirm or deny his assumptions. Additionally, the use of multiple sensors is very effective at defeating an adversary's camouflage, concealment, and deception efforts.[9]

A discussion of the terms reconnaissance and surveillance provide a perspective on real-time collection requirements. First, the terms real-time and near real-time need a little clarifying. Real-time denotes information transmitted directly from a sensor to the user and near real-time includes the addition of a brief period of time (second or minutes) for automated or operator assisted processing to take place. [10] The terms are synonymous for this discussion and for simplicity only real-time will be used. The terms surveillance and reconnaissance are also used interchangeably, the difference is one of employment or purpose. Reconnaissance describes a mission to collect information about an adversary or

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[8] Ibid, 21.
[9] Joint Chiefs of Staff, Joint Intelligence Support to Military Operations (Joint Pub 2-01) (Washington, D.C.: November 20, 1996), III-11 - III-12.
[10] The Joint Chiefs of Staff, Concepts for Joint Operations: Expanding Joint Vision 2010, May 1997, 86.

area of interest; an example would be a Special Forces mission to ascertain specific details about a target. The definition of surveillance is similar, but denotes systematic observation of an area of interest; an example would be a Special Forces mission to monitor the activity of an enemy center of gravity.[11] Although a somewhat esoteric discussion, this difference between these terms defines the objective and procedures for a collection mission, which in the case of real-time awareness should be surveillance.

Several additional ISR collection terms must be described to understand how sensors can be used collaboratively to conduct surveillance. The field of view of some sensors, like imagery, is very narrow and coverage of an area either requires the use of multiple narrow view sensors or the addition of a sensor with broad area coverage, like signals intelligence for cueing. This concept is called cross sensor cueing and changing the target or focus of a sensor in real-time is termed dynamic re-tasking.[12] Geolocation is a term used to describe the ability of a sensor system to determine a position on an item of interest, while precision geolocation denotes a position with sufficient accuracy for targeting. When the data about a target from different sensors and sources is put together by an analyst or computer algorithm the process is termed fusion.[13] Fusion of multi-source intelligence and sensor data is a key concept in JV 2010 for building the battlespace picture that is called DBA.

III. Platform Types and Disciplines of Intelligence Collection

[11] Joint Chiefs of Staff, Joint Intelligence Support to Military Operations (Joint Pub 2-01) (Washington, D.C.: November 20, 1996), GL-12 - GL-13.
[12] Robert Wall, "The Electronic Triad", Air Force Magazine, January 1998, 57.
[13] Joint Chiefs of Staff, Doctrine for Reconnaissance, Surveillance, and Target Acquisition Support for Joint Operations (Joint Pub 3-55)(Washington, D.C.: April 14, 1993), II-1.

The fusion of all-source intelligence with the fluid integration of sensors, platforms, command organizations, and logistic support centers will allow a greater number of operational tasks to be accomplished a lot faster.

Joint Vision 2010[14]

A basic understanding of the tools available for intelligence collection is essential to understand how these systems can be used together to achieve dominant battlespace awareness. There are two major elements to a collection system: the first is the platform and the second is the type or discipline of the sensor. Each system is endowed with its own collection of capabilities and weaknesses. The types of collection platforms available to the Joint Force Commander are airborne, subsurface, surface, and national systems.[15] The five collection disciplines are signals intelligence (SIGINT), imagery intelligence (IMINT), measurement and signature intelligence (MASINT), human source intelligence (HUMINT), and open-source intelligence (OSINT).[16] This brief survey will highlight the need for multiple types of platforms and sensors to create a picture of the battlespace and the additional challenges to achieve a real-time picture.

The four platform types present significant planning challenges for a Joint Force Commander because they each have different fields of view, duration on station, stealth, and vulnerability.[17] Airborne systems which are the JFC's most visible organic assets will be discussed in the most detail and the other platform types will be mentioned in comparison. Airborne systems have a very good field of view because of their altitude. The potential detection range for a target at sea level varies by the aircraft's altitude; examples are 36 NM.

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[14] The Joint Chiefs of Staff, Joint Vision 2010, undated, 13.
[15] Joint Chiefs of Staff, Doctrine for Reconnaissance, Surveillance, and Target Acquisition Support for Joint Operations (Joint Pub 3-55)(Washington, D.C.: April 14, 1993), II-3.
[16] Director of Central Intelligence, A Consumer's Guide to Intelligence, CIA, July 1995, 2-3.
[17] Joint Chiefs of Staff, Doctrine for Reconnaissance, Surveillance, and Target Acquisition Support for Joint Operations (Joint Pub 3-55)(Washington, D.C.: April 14, 1993), II-3 - II-9.

at 1,000 feet, 200 NM at 30,000 feet, and 300 NM at 65,000 feet.[18] The field of view can be significantly affected by terrain obstructions. Airborne system duration on station varies by platform and distance from the air base, but is relatively brief and generally ranges between one and ten hours on station. New platforms like the Global Hawk unmanned aerial vehicle (UAV) will have an endurance of up to 38 hours.[19] ISR aircraft are vulnerable to air defense weapons systems with the exception of the stealthy DarkStar UAV. Aircraft carry all types of sensors and are generally seen as the most mobile and responsive assets available to a JFC.[20]

The other types of platforms trade field of view for duration on station. Subsurface systems have a very short field of view, although unusual ranges for reception of electromagnetic waves may occur over water with an atmospheric condition known as ducting.[21] Subsurface examples are submarines and unattended seismic sensors, which can provide covert long-term surveillance, however operations security may limit transmission of information.[22] Surface platform sensors have equally short ranges, with the reception of high frequency electronic emissions being an exception. Surface systems range from manned reconnaissance patrols, counter-battery radars, surface ships, and special operations forces' special reconnaissance operations. These systems can support extended duration missions

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[18] David R. Frieden, ed., Principles of Naval Weapons Systems, (Annapolis, MD: Naval Institute Press, 1985), 24.
[19] Defense Airborne Reconnaissance Office, UAV Annual Report FY 1997, (Washington: November 1997), 23.
[20] Joint Chiefs of Staff, Doctrine for Reconnaissance, Surveillance, and Target Acquisition Support for Joint Operations (Joint Pub 3-55)(Washington, D.C.: April 14, 1993), II-4.
[21] David R. Frieden, ed., Principles of Naval Weapons Systems, (Annapolis, MD: Naval Institute Press, 1985), 24
[22] Joint Chiefs of Staff, Doctrine for Reconnaissance, Surveillance, and Target Acquisition Support for Joint Operations (Joint Pub 3-55)(Washington, D.C.: April 14, 1993), II-5.

and special reconnaissance operations can provide the most complete understanding of a high value target.[23]

The most visible of the national systems are the space systems. Space systems have the potential to provide the largest field of view, are worldwide, have a deep look capability, and are relatively invulnerable to enemy action.[24] The disadvantages of these systems are that their schedules are predictable, weather affects some sensors, and a JFC must compete with theater and national requirements. Some examples are satellites for the early detection of ballistic missile launch and meteorological observation.[25] The JFC receives either direct downlink or relayed satellite sensor data form the service component Tactical Exploitation of National Capabilities Program (TENCAP) systems.[26] Commercial satellite systems are now available to augment the national capability, but are also available to an adversary.[27] Although a JFC has a vast option of platforms that can provide information, frequently choices between coverage areas will have to be made because total and continuous surveillance of a large area of interest like Iraq would be very difficult to provide. Assured surveillance of an area implies a continuous awareness of any coverage blind spots in order to prevent the self-delusion that the absence of activity on a DBA screen is absolutely an absence of activity.

These multiple platform types are mated with sensors, which provide information of different types or disciplines. Discipline is a very apt description because there is a distinct knowledge base required to collect information reliably with any system. Also, each discipline can be seen to provide two levels of detail, the first being an indication of activity

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[23] Ibid, II-6.
[24] Ibid, II-7.
[25] Ibid, II-8.
[26] Ibid, II-8 - II-9.

or location and the second being specific information derived from or about the target of interest. Additionally, each sensor was constructed to maximize certain attributes, which frequently come at the expense of others. These sensor design trades make the collection operator essential to ensuring that the sensor is mission focused and only validated information is disseminated. Finally, intelligence collection is an active process, because an adversary will frequently take actions like concealment, camouflage, deception, emission control, and operational security to deny information.[28]

The signals intelligence (SIGINT) discipline derives information from intercepted communications, radar, and telemetry.[29] SIGINT is a passive collection technique and is generally associated with the interception of foreign radio frequency emissions. SIGINT sensors are frequently described as providing broad area coverage with general locating capability.[30] Systems that are very close to the emitter or achieve locations cooperatively through multiple platforms like the Army GUARDRAIL system can achieve targeting location accuracy.[31] SIGINT is composed of Communications Intelligence (COMINT) and Electronic Intelligence (ELINT). Each of these disciplines can provide qualitative information beyond location data that may identify, reveal the purpose of or intentions of the emitter.[32] Additionally, the ability to detect, analyze, and exploit information is directly related to the design of the system with examples being the number of receivers, sensitivity, search strategy, familiarity with the target environment, automatic recognition filters and

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[27] Ibid.
[28] Joint Chiefs of Staff, Joint Intelligence Support to Military Operations (Joint Pub 2-01) (Washington, D.C.: November 20, 1996), III-12.
[29] Director of Central Intelligence, A Consumer's Guide to Intelligence, CIA, July 1995, 2-3.
[30] A.G. Self, "The Littoral – Some Implications for ESM systems", Journal of Electronic Defense, January 1997 Supplement, 60-63.
[31] TRW, Guardrail Airborne Surveillance System, (Sunnyvale, CA: TRW marketing brochure, 1997), 2-4.
[32] Jeffery T. Richelson, The U.S. Intelligence Community, (Boulder, CO: Westview Press, 1995), 171-175; Don Herskovitz, "The Other SIGINT/ELINT", Journal of Electronic Defense, April 1996, 35-40.

number of operators.[33] Clearly, the capability for SIGINT to provide real time assured awareness depends on the type of system, operator proficiency, and the ability to focus the mission toward specific signals of interest.

Imagery Intelligence (IMINT) is quickly growing in capability with the advent of digital collection systems and the fielding of processor intensive analysis systems. There are many types and characteristics of imagery, but the main split is between passive systems and active systems. Examples of passive systems are electro-optical, infrared, multispectral, and film which rely on the emission or reflection of energy and are affected by weather and time of day.[34] The most common active imaging sensor is the synthetic aperture radar (SAR) which has all weather and day/night capabilities.[35] The Joint Surveillance Targeting Attack Radar System (JSTARS) is the most capable SAR system, but is still limited by its sensor field of view, target area terrain, and any stand-off distance required for self-protection.[36] IMINT's two key attributes are the high level of awareness inherent in an image and the utility for precision targeting. The drawback is that the images with the best resolution have the smallest area of coverage and can be described as looking at the battlespace through a straw. The Army's RC-7B Airborne Reconnaissance Low aircraft utilizes moving target indicator (MTI) recognition capability and selectable wide (90 deg.) to narrow search (2 deg.) in order to meet the detection and resolution requirements.[37] The Predator UAV system is frequently described as creating battlespace awareness because its video imagery broadcast in near real-time to National and theater level command and control sites through

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[33] Dave Adamy, "EW 101 Tutorial: Search Strategies Using Wideband Receivers", Journal of Electronic Defense, April 1998, 151-158.
[34] Jeffery T. Richelson, The U.S. Intelligence Community, (Boulder, CO: Westview Press, 1995), 151-158.
[35] Ibid, 151.
[36] David A. Fulghum, "Multisensor Observations Key to Army's RC-7", Aviation Week & Space Technology, November 24, 1997, 60-61.
[37] Ibid.

the Joint Broadcast System. Task Force or theater commanders have the ability to retask the aircraft and sensor by radio or telephone while watching the image.[38]

Compared to IMINT and SIGINT the intelligence disciplines of HUMINT, MASINT, and OSINT have limited roles in real time battlespace awareness. Their products are exceptionally valuable to intelligence preparation of the battlefield, but have infrequent reporting time-lines, significant processing delays, or do not easily fit into a display of the battlefield. Products from these disciplines may also cue IMINT or SIGINT sensors. Future sensor capabilities, like the proposal to outfit RC-135S Cobra Ball aircraft with lasers capable of detecting chemical and biological attack, will also have significant promise for full dimensional protection.[39] The clear lesson is that there are some incredibly capable ISR sensors, but they must be scheduled efficiently to be properly positioned, responsive to external cueing, and continuously managed to exploit collection opportunities.

IV. Reconnaissance Collection Doctrine

"What the Warrior Needs: a fused, real time, true representation of the battlespace – an ability to order, respond and coordinate horizontally and vertically to the degree necessary to prosecute his mission in that battlespace."

The C4I for the Warrior Vision[40]

A review of current ISR collection doctrine illustrates the challenges of real-time collection. Overall, ISR doctrine describes the collection management process and the types of reconnaissance missions. Collection management defines the process for requesting,

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[38] Defense Airborne Reconnaissance Office, UAV Annual Report FY 1997, (Washington: November 1997), 23.

[39] John A. Tirpak, "Complications Overhead", Air Force Magazine, April 1998, 28; David A. Fulghum, "Cobra Ball's Expanding Role Upgrades Offer New Mission Options", Aviation Week and Space Technology, August 4, 1997, 56.

[40] Joint Chiefs of Staff, Doctrine for Command, Control, Communicaitons, and Computer (C4) Systems Support to Joint Operations (JCS Pub 6-0)(Washington, D.C.: May 30, 1995), I-1.

scheduling, and tasking reconnaissance systems. ISR systems are employed in the following mission areas: order of battle, indications and warning, and assessment operations.[41] The reconnaissance mission areas describe how reconnaissance sensors are employed and will be explored first.

The conduct of each mission area remains very similar across strategic, operational, and tactical operations. Planning and employment or order of battle operations can be characterized as data base generation and maintenance during pre-hostilities.[42] Post-hostilities operations also monitor enemy force deployment and location, but primarily for targeting or target system cueing. Indications and warning (I&W) operations provide information on enemy forces, systems and installations that threaten U.S. or allied forces. I&W examples are the strategic monitoring for arms control agreements, the tactical warning of surface to air missile system activity, or the detection of mobilization for attack by a moving target indicator.[43] Assessment operations are employed before, during, and after military operations to monitor the effects of friendly deception efforts or to provide combat assessment to evaluate the need for follow-up or new operations.[44] The collection manager, a function of the JFC's intelligence staff, generates reconnaissance system employment plans.

Collection management is the process of identifying what information to collect and how to collect it. The first process of defining the collection requirements can be summarized as consolidating and prioritizing the requests for information (RFI) and priority

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[41] Joint Chiefs of Staff, Doctrine for Reconnaissance, Surveillance, and Target Acquisition Support for Joint Operations (Joint Pub 3-55)(Washington, D.C.: April 14, 1993), I-1 – I-4.
[42] Ibid.
[43] Ibid; David A. Fulghum, "Army Spy Aircraft Watch North Korea", Aviation Weekly and Space Technology, November 24, 1997, 58-59.
[44] Joint Chiefs of Staff, Doctrine for Reconnaissance, Surveillance, and Target Acquisition Support for Joint Operations (Joint Pub 3-55)(Washington, D.C.: April 14, 1993), I-3.

intelligence requirements (PIR) from subordinate commands and the JFC staff.[45] Next the individual requirements are evaluated on the best type or types of sensors and platforms for the collection. This matures into a collection plan with specific platforms tasked. Generally, organic assets are tasked first and then requests for National or higher echelon resources are submitted for the remaining priority requests. The JFC's J3 will validate platform assignments and issue the mission tasking orders. Most unified and specified commands have a joint reconnaissance center as a part of the J-3 staff to manage the operations of theater and occasionally some corps level reconnaissance assets.[46] This management is generally limited to the scheduling and monitoring of sensitive operations. The conduct of each mission is the responsibility of the unit commander who was tasked.[47] The collection plan is continuously updated based on changing requirements and feedback on the quality and timeliness of the collection products.[48]

After the sensor platforms are positioned within the battlespace, doctrine expresses a goal to bring sensor data directly to a central C4I system where it is fused. Current procedures have the J2 responsible for all processing equipment and any required communications connectivity must be coordinated between the J-2 and the J-6. Thus, current doctrine does not provide a process for real-time capability.

This current reconnaissance collection doctrine is heavily biased toward the static planning process and reflects the stovepipe architecture of many current systems. Also, a case can be made that the origins for collection doctrine comes from preplanned Cold War order of battle missions and the procedures com from requirements for the prioritization and

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[45] Joint Chiefs of Staff, Joint Intelligence Support to Military Operations (Joint Pub 2-01) (Washington, D.C.: November 20, 1996), III-12 - III-13.
[46] Department of Defense, Final Report to Congress: Conduct of the Persian Gulf War, July 1992, C-7.

lead time needs of national intelligence resources, such as satellite imagery. Existing doctrine does not provide the process to inject new information into the collection plans after the missions are initiated. Some of the specific shortfalls experienced during the Gulf War were: lack of combat assessment (quality and quantity), need for all-weather near-real time coverage, inability to get information to the tactical level, lack of broad area coverage, and lack of interoperability.[49] Although doctrine discusses real time collection concerns of timeliness, geolocation accuracy, survivability, reliability, suitability, and connectivity, it does not have a process or recipe to create a real time picture of the battlespace.[50]

V. Early Air Defense Model

[The semi-automatic ground environment air defense system] was designed to control and fight the air defense battle. To do so effectively required prompt and accurate information of enemy movements, not only flowing from sectors to combat operations centers but also needed as soon as possible after the enemy left his bases.

The Emerging Shield[51]

The early air defense organization in the United States provides a valuable model for achieving assured awareness. During this era, capabilities advanced from Army Air Corps experiments in the 1930's to a North Atlantic Air Defense (NORAD) Organization in the late 1950's with 3,000 interceptor aircraft, 215 early warning radar sites and 90 surface to air missile sites.[52] The British lessons from the Battle of Britain, the fear of another Pearl

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[47] Joint Chiefs of Staff, Joint Intelligence Support to Military Operations (Joint Pub 2-01) (Washington, D.C.: November 20, 1996), III-24 - III-25

[48] Ibid, III-9 - III-23

[49] Kenneth R. Israel, "DARO Vision for the Next Millenium", Proceedings of the Intelligence, Surveillance, and Reconnaissance Conference, Association of Old Crows, Moffett Field, CA Nov. 18-20, 1997, 15-16.

[50] Joint Chiefs of Staff, Doctrine for Reconnaissance, Surveillance, and Target Acquisition Support for Joint Operations (Joint Pub 3-55)(Washington, D.C.: April 14, 1993), II-9 - II-11.

[51] Kenneth Schaffel, The Emerging Shield: the Air Force and the Evolution of Continental Air Defense, 1945-1960, (Washington, D.C.: United States Air Force Office of Air Force History, 1990), 209.

[52] Report of the Special Committee of the Senate on National Defence, Canada's Territorial Air Defence, (Ottawa, Canada: January 1985), 5.

Harbor, and the 1949 detonation of a nuclear bomb by a hostile Soviet Union were the rationale for creating an air defense shield around the United States.[53] The 3,000 interceptors by themselves could not patrol the vast U.S. and Canadian border; they needed threat axis information. Thus, there was the requirement for the assured and early detection of a bomber attack.

Early air defense warning systems relied on visual or audio detection by ground observers. These observers were organized in a hierarchical nature from observation post, to filter center, to regional information center, and finally to an air defense command.[54] The information would start with a sighting by a single observer who would forward it to a filter center were the information was consolidated and verified with other observations and knowledge of friendly flight activity. This information was sent to a regional information center, which maintained a more complete picture and forwarded the information to the air defense center and pursuit or interceptor squadrons. The air defense center consolidated the regional pictures and had command over the interceptor squadrons.[55] Ground observers remained an active part of air defense warning until 1959 and peaked at a force level of 305,000 volunteer civilians in 1953.[56]

The introduction of radar greatly improved the air defense capabilities. The organization used for observers was initially retained as radar stations were added below regional information centers. As radar improved its role expanded into early warning and ground controlled intercept sites. In the early 1950's information flowed from observation posts to filter centers or from radar stations to regional direction centers, then on to Eastern

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[53] Kenneth Schaffel, The Emerging Shield: the Air Force and the Evolution of Continental Air Defense, 1945-1960, (Washington, D.C.: United States Air Force Office of Air Force History, 1990). 79.
[54] Ibid, 26-28.
[55] Ibid, 30.

or Western Air Defense Force operations centers, and ultimately to the Air Defense Command's Combat Operations Center in Colorado.[57] By 1959 NORAD operated three lines of early warning radars providing up to six hours notice of bomber attack and all assets were controlled by the world's first computerized command and control system.[58]

Applying the early air defense organization to today's battlespace awareness challenge has considerable merit. With the need for continuous and assured information a JFC can operate an information center. The responsibility of this information center would be to maintain a continuous picture of the battlespace by managing the location and focus of sensors and sources. The JFC information center would be organized to filter multiple sources, identify activity or change, dynamically retask sensors to identity or validate new activity and create pockets of assured or dominant battlespace awareness. This organization would not preclude automated fusion, sensor to shooter applications, or any other C4I system concept. What it does do is create someone responsible for the real-time management of awareness assets, permit the injection of highly classified intelligence for cueing, and not require a JFC to be intimate with the technical limitations of each sensor. Technology would permit U.S. based, airborne, ground or shipboard information control centers depending on the maturity of the theater, the nature of the operation, and the assets and resources available to the JFC.

VI. Examination of the Leading RMA Paradigms

__Advanced C4I__ is the subsystem that rests on technologies associated with transferring information and sifting through data to extract information. It is the system that converts the

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[56] Ibid, 159-222.
[57] Ibid.
[58] Ibid.

information derived from battlespace awareness into deeper knowledge and understanding of the battle space ...

The Emerging System of Systems
Admiral William A. Owens[59]

The ability to achieve the concepts of Joint Vision 2010 is dependent upon the realization of one of several information technology based paradigms for a revolution in military affairs (RMA). The heart of these paradigms is the use of information, communications and computer technology to translate intelligence, surveillance and reconnaissance (ISR) sensor information into a picture of the battlefield that is shared throughout the Joint Task Force. By developing some reconnaissance collection synergy measures of effectiveness, the three leading paradigms can be evaluated on their ability to achieve real-time dominant battlespace awareness. The paradigms discussed will be the system of systems, the corporate information system, and network centric warfare.

The key to collecting a dominant awareness of surface activity is achieving a synergy between multiple sensors. Throughout this discussion several conclusions have been drawn and these will be brought forward as real-time ISR collection measures of effectiveness. The first is the awareness of the gaps in sensor coverage. The second is the ability to achieve cross sensor cueing and the dynamic retasking of sensors. The next measure of effectiveness is the presence of a process or operator that can recognize adversary operational patterns. The fourth is the ability to introduce highly classified or intentions based information for cueing. Together these concepts provide a yardstick to evaluate differing paradigms on their ability to achieve assured real-time Dominant Battlespace Awareness.

The heart of the system of systems paradigm is expressed in the quote above from Admiral Owen. The C4I sub-system can be imagined as a black box where disparate sensor

[59] William A. Owens, "The Emerging System of Systems", U.S. Naval Institute Proceedings, May 1995, 37-38.

information is transformed into a cohesive picture of the battlespace. This paradigm does not address the challenges of managing ISR sensors, although it does provide a method to better understand and use the information collected. Without a methodology to synchronize the collection of sensors the system of systems paradigm does not meet three of the four collection methods of effectiveness. This paradigm has the capability to recognize operational patterns, but only if they had been anticipated and included in the C4I system's database.[60] Overall, this paradigm would greatly improve battlespace awareness, but without the addition of a real-time sensor management strategy the assurance and completeness required by JV 2010's operational concepts can not be met.

The corporate information system paradigm can be viewed through the example of Wal-mart's system.[61] It consists of a series of sensors at the registers, which provide near real-time updates of the corporate inventory and sales databases. Suppliers, managers, and the chief executive officer can then access these databases in parallel. Because actions are happening in parallel and not in series, the lead times for most decisions are eliminated and a tremendous cost and responsiveness advantage is gained by Wal-Mart.[62] Unfortunately, in the military context with an uncooperative adversary and non-homogeneous sensor outputs this application has limits. The foundation for this model is assured database information and this implies a layer of sensor coordination, deconfliction, and verification between sensors and the common databases. This paradigm does not match any of the four synergy measures of effectiveness.

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[60] Ibid, 38.
[61] Arthur Cebrowski and J. Garstka, "Network-Centric Warfare Its Origin and Future", U.S. Naval Institute Proceedings, January 1998, 32.
[62] Ibid.

The third RMA paradigm is the network centric concept fostered by Vice Admiral Cebrowski. The network centric concept is based on an interconnected network of sensor, information, and engagement grids.[63] This concept includes total force "access to all appropriate information sources", "integrated sensor grids closely coupled in time to shooters and C2 processes", and the idea of self-synchronization.[64] The war fighting example used is the cooperative engagement capability (CEC) were multiple air search radar pictures are brought together to form a more complete picture and any platform can use that information to engage air targets.[65] This concept implies that sensors can be positioned to obtain near absolute assurance of detection and the data set in both is controlled and very homogenous. Like the corporate information system paradigm it does not address the need to manage the limitations of reconnaissance sensors to maintain assurance of information. A logical model diagram does show a command loop back to the sensors and an information loop from the shooters.[66] Although this should improve sensor responsiveness or focus, it does not create sensor synergy. This model implies a continuous flow of sensor data until an external query is received. In practice this would be intermittent and not considered active management. Additionally, this paradigm implies either users be familiar with the collection disciplines or the need for C4I fusion applications at each node in order to create a complete picture of the battlespace.

Without a single controlled awareness being formed, the probability for mis-synchronization is equally as possible as self-synchronization. Although a vast quantity of information will be available, the responsibility for comprehension is left up to each node,

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[63] Ibid.
[64] Ibid, 33-35.
[65] Ibid, 34.
[66] Ibid, 33.

whether an individual or weapons system. Some level of synergistic collection is possible through self-synchronization, but it is not assured and will probably be inconsistent. This paradigm does not meet the ISR collection synergy measures of effectiveness because it does not show the user where or what the networked sensors are not capable of seeing and will potentially create a false sense of security. Also, cross sensor cueing is not ensured although it is implied that the collectors will be self-synchronizing to changes. Without specific direction operators will be force to time-share between operating their sensors and surfing for changes in the overall picture. Finally, cueing from operational patterns or external sources is not tied directly to sensors, is very distributed, and if achieved would be erratic. Just like the corporate information system, the distributed nature of the network centric model requires an assured sensor picture more than the system of systems. Assured real-time collection must produce a single battlespace picture, before network centric warfare can achieve its potential.

VII. Conclusion

...[Joint Vision 2010] established a conceptual blueprint for transforming emerging concepts and technologies into joint operational capabilities ... The next task is to operationalize JV 2010 – transforming its concepts of joint warfighting into reality.

General Henry H. Shelton
Chairman of the Joint Chiefs of Staff[67]

The concept of actively managing dominant battlespace awareness is critical to operationalizing Joint Vision 2010. It is unrealistic to expect total knowledge of an adversary, but shrewd and active management of collection sensors can provide pockets of dominant battlespace awareness. Just as the process of intelligence preparation of the

battlefield can be compared to assembling a jigsaw puzzle, achieving real-time DBA can be compared to conducting an orchestra. Where intelligence preparation of the battlefield and collection planning provide the musical score, each sensor provides a unique sound, and music is only produced when a conductor brings all of the sensors together.

Both of the system of systems and the network centric paradigms show improvement, but currently overlook sensor management. They try to create a synergy of information without first creating a synergy of sensors. The early air defense organizational model holds promise to fill this niche. By organizing someone becomes responsible for DBA, sensor information will be deconflicted and validated, awareness of sensitive information operations can be incorporated, and the outputs can be tailored to the Joint Force Commander. Current airborne and surface systems can be designated or modified to be the information center. Concepts like the Information Superiority Air Expeditionary Force, comprised of E-3A, RC-135, and E-8 aircraft, could be designated as the information center for an immature theater.[68] Hierarchical information centers could be formed at division, corps and theater levels to ease information flow during a campaign.

There are many challenges presented by Joint Vision 2010, but the one of achieving Dominant Battlespace Awareness becomes more achievable for the Joint Force Commander of 2010 with a responsible individual straddling the information flow. This organizational concept does not prevent or reduce the amount of automation in the flow of information. It does provide for a knowledgeable and responsible conductor of collection operators and manager of situations not anticipated by C4I system programmers. Dominant Battlespace Awareness must be actively orchestrated at the operational level of war.

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[67] Shelton, Henry H., "A Word from the New Chairman", Joint Force Quarterly, Autumn/Winter 1997-98, 6.
[68] Robert Wall, "The Electronic Triad", Air Force Magazine, January 1998, 55.

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